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I. SUMMARY

On July 12, 1988, The National Institute for Occupational Safety and Health (NIOSH) received a request from employees at the Lutheran Medical Center in Brooklyn, New York, who were concerned that a variety of noxious odors evident in the hospital might be originating from the medical center's pathological waste incinerator, and that exposures to these materials could be affecting their health. Employees reported headaches, nausea, hair loss, and dermatitis as a result of exposure to these odors.

On November 29, 1988, NIOSH investigators conducted a preliminary evaluation of conditions at the hospital and interviewed workers to determine the extent of their work-related health complaints. Confidential interviews with eight workers in the Nursery, Pediatrics, and Materials Delivery Departments (departments initially identified by the requesters as problem areas), showed that two (25%) of the eight workers regularly experienced nausea, headaches, dry scratchy throat, and burning eyes. They reported that these symptoms followed episodes of foul odors in their work areas. Each of the remaining six workers indicated episodic occurrences of odors, but stressed that they were neither of a regular nor consistent odor. The Nursery Neonatal Intensive Care Unit (NICU) was identified as an area that had frequent episodes of noxious odors, and employees reported that patients in this area were evacuated on one occasion due to unidentified odors.

On April 3-6, 1989, NIOSH investigators conducted an industrial hygiene survey and tracer-gas study to evaluate the potential for reentry of incinerator exhaust emissions into the hospital's ventilation systems. Sulfur hexafluoride (SF_6) tracer-gas was released into the incinerator exhaust stack and air samples were then collected inside the hospital to detect the presence of SF_6. The results showed the presence of SF_6 inside the fresh-air supply ducts in the two rooms where measurements were collected, indicating that incinerator emissions were reentering the hospital through the ventilation systems. However, because of the high rate of dilution of emissions found, it is unlikely that any contaminant would be found in concentrations above the NIOSH evaluation criteria. Even so, due to the low odor thresholds for some of the identified substances, objectionable odors might be detectable by hospital employees at extremely low concentrations.

Carbon dioxide (CO_2) concentrations measured throughout the hospital were all below the NIOSH indoor air quality guidelines for CO_2. Temperature and relative humidity measurements were above the guidelines set by the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) in a few office locations. All total and respirable particulate sample results were less than 5% of the NIOSH Recommended Exposure Limits (REL) and all metals results were less than 1% of the NIOSH RELs. Qualitative samples screened for volatile organic chemicals via gas chromatography identified toluene, xylenes, isopropanol, various aliphatic hydrocarbons, and branched alkanes. Based on the qualitative sample results, quantitative samples were analyzed for isopropanol, 1,1,1-trichloroethane,

trichloroethylene, toluene, xylenes, limonene, and total hydrocarbons. All substances included in the qualitative analyses were less than 1% of the NIOSH RELs. It should be noted that the NIOSH RELs are generally designed for "industrial" environments (i.e., incinerator room), and are not adequate for assessing the indoor air quality of "non-industrial" areas (i.e., the nursery, patient rooms, administrative offices). However, the low concentrations found in the "IAQ areas" of the hospital would not be expected to cause health problems.

The incinerator operator and at least one other hospital employee were required to wear a half-mask cartridge respirator when performing certain aspects of their jobs. However, the hospital did not have a written respiratory protection program in place at the time of the NIOSH surveys.

The tracer-gas evaluation showed that reentrainment of incinerator/ scrubber stack emissions is possible under certain meteorological conditions. However, there were no documented overexposures to any of the chemical substances evaluated. There was no written respiratory protection program in place at the time of the NIOSH survey. Recommendations for establishing a written respiratory protection program are made, and in the event that the pathological waste incinerator is ever restarted, recommendations for evaluating the effect of stack height and/or modification of the air handling unit fresh air-intakes are provided in Section IX.

KEYWORDS: SIC 8062 (General Medical and Surgical Hospitals), 4953 (Refuse systems), hospital refuse, incineration, metals, particulates, tracer gas, sulfur hexafluoride.

II. INTRODUCTION

On July 12, 1988, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request from employees of the Lutheran Medical Center, Brooklyn, New York, to evaluate the health consequences of exposure to noxious odors which they believed to be originating from the hospital's pathological waste incinerator. Employees reported that vapors from the sixth floor incinerator were being spread throughout the hospital. Employees further indicated that infectious waste disposal practices and the manner in which the incinerator was operated were unnecessarily exposing workers to hazardous materials.

On November 29, 1988, NIOSH representatives conducted a site visit and toured the hospital to determine the cause and extent of employee complaints. An opening conference was attended by representatives of the management, the Hospital Workers Union, Local 1199 (representing hourly employees), and the United Federation of Teachers (representing nurses), followed by a walk-through inspection of the hospital pathological waste incinerator room, incinerator scrubber room, and roof. Interviews with employees randomly chosen from the Materials Delivery, Nursery, and Pediatrics Departments suggested that the Neonatal Intensive Care Unit (NICU) was affected by intermittent episodes of noxious odors. Two of eight employees (25%) described symptoms of upper airway irritation and nausea during the NICU odor episodes. Since, the two affected employees described symptoms of possible irritation, that could be controlled by removing the source of irritant exposure, this Health Hazard Evaluation was directed at assessing the hospital's ventilation system for potential reentrainment of emissions from the hospital's pathological waste incinerator.

A review of ventilation diagrams obtained from the Hospital Facilities Manager showed that Air Handling Unit (AHU) #4 served the nursery. In addition, pictures, provided to the NIOSH team by the confidential requesters showed that the incinerator exhaust plume flowed down across the hospital roof line where the AHU fresh-air intakes were located.

On April 3, 1989, a team of NIOSH investigators returned to Lutheran Medical Center. An opening conference with management and union representatives was conducted to summarize the purpose of this follow-up visit. On April 4-6, 1989, environmental samples were collected, and a tracer-gas study of the ventilation system was conducted to determine if emissions from the pathological waste incinerator could be reentering the building through the AHUs on the roof of the hospital. On April 7, 1989, a closing conference with management and union representatives was held to inform all interested parties of the preliminary findings of the follow-up survey. On May 19, 1989, an interim report summarizing the preliminary findings was submitted in writing to management and union representatives.

III. BACKGROUND

Lutheran Medical Center is a 532 bed comprehensive health care center employing approximately 2300 workers. The hospital was founded in 1883 by the Evangelical Lutheran Church in America and was located in Brooklyn, New York, at 4th Avenue and 45th Street. In 1977 the hospital moved into its present location, a renovated warehouse building that was constructed in 1914 and remodeled (1974-1977) to accommodate the Lutheran Medical Center's needs.

The pathological waste incinerator is located in a partial 6th floor that covers a portion of the roof. The incinerator is manually loaded and employs two stage combustion followed by a scrubber for final control of emissions. Incinerator emissions pass through the scrubber located in the penthouse above the incinerator room before being released to the outside atmosphere. The scrubber stack extends beyond the roof of the penthouse by approximately 8 feet, and the top of the stack is estimated to be approximately 35 feet above the roof of the medical center building.

Air handling units (AHUs) are contained within fan enclosures on the roof of the 5th floor at varying distances from the incinerator/scrubber stack. The fan enclosures are large rectangular structures with air intakes and exhausts on the sides and ends. Figure 1A is a drawing of the top view of the roof of the medical center showing the location of the incinerator/scrubber stack in relation to the fresh-air intakes for the two AHUs examined in this study. Figure 1B is a drawing of the side view of the same area showing the relative vertical positions of the AHUs in relation to the incinerator/scrubber stack.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

On November 29, 1988, an initial walk-through survey of the Hospital was conducted. Drawings of the ventilation systems were obtained and reviewed. Plans to conduct airborne sampling for incinerator emissions were postponed due to scheduled maintenance on the incinerator unit.

On April 3-7, 1989, environmental samples were collected, and a tracer-gas study of the hospital's ventilation systems was conducted. Sampling pumps and the appropriate sampling media were placed in groups at various locations throughout the hospital. Each group of samples collected contained environmental sampling media for total particulates, respirable particulates, metals, and qualitative and quantitative samples for volatile organic chemicals. Samples collected included both general-area air samples and personal breathing-zone air samples.

Carbon dioxide (CO_2) samples were obtained using a Gastech direct reading Portable CO_2 Monitor (Model RI411). Indoor CO_2 concentrations were obtained at various locations throughout the hospital, and ambient CO_2 samples were collected outside the building for comparison. Temperature and relative humidity data were collected in conjunction with CO_2 measurements in all areas where airborne sampling was conducted, using a Vista Scientific Corporation psychrometer (Model #784).

Total particulate samples were collected on pre-weighed polyvinyl chloride (PVC) filters connected via Tygon tubing to battery-powered sampling pumps calibrated to provide a volumetric airflow rate of 2.0 liters per minute (lpm). Respirable particulate samples were collected on pre-weighed PVC filters attached to a 10-millimeter cyclone and connected via Tygon tubing to battery-powered sampling pumps calibrated to provide a volumetric airflow rate of 1.7 lpm. The total and respirable particulate filters were analyzed gravimetrically for total and respirable particulate according to NIOSH Methods 0500 and 0600,[1] respectively. The filters were then analyzed via inductively coupled argon plasma-atomic emission spectroscopy (ICP-AES) according to NIOSH Method No. 7300,[1] a method which provides for the simultaneous analysis of 28 metals of toxicological importance.

Qualitative and quantitative samples were collected on charcoal tubes connected via Tygon tubing to battery-powered sampling pumps calibrated to provide a volumetric airflow rate of 1.0 lpm and 0.1 lpm, respectively. These samples were analyzed via gas chromatography/mass spectrometry (GC/MS). Qualitative samples were screened for volatile organic chemicals (VOCs) and quantitative samples were analyzed for specific compounds as indicated by the qualitative analytical results.

B. Tracer-gas Evaluation

A tracer-gas technique was used to evaluate the potential for reentry of emissions from the pathological waste incinerator into the building ventilation systems. One-hundred percent sulfur hexafluoride (SF_6) gas was used as the tracer. SF_6 is non-toxic, chemically inert, thermally stable, and does not generally occur in ambient air. It is also easily detectable at very low concentrations by gas chromatography using an electron capture detector.

A Baseline Industries, Inc., Gas Chromatograph, Model 1030A, with an electron capture detector was used for detection of SF_6. This instrument incorporates a built-in microprocessor and sampling valve, enabling continuous sampling and automatic repetition of the sampling and injection cycle. The chromatographic peaks were recorded on an external recorder. The gas chromatograph was calibrated using commercially prepared standards containing from 0.01 parts per billion (ppb) to 30 ppb of SF_6 in air. Air was sampled using the gas chromatograph and a flow control system to assure that air samples and calibration standards were supplied to the gas chromatograph at the same flow rate and pressure. A particulate filter was located in the sampling line to remove particulates and protect the instrumentation. A sampling cycle of four minutes was used.

Building drawings obtained from the hospital engineering department were reviewed to determine which areas of the hospital were served by the various AHUs. AHU #1 and AHU #4 were chosen for evaluation because of their proximity to the incinerator/scrubber stack and the fact that these AHUs served locations which were indicated as problem areas. AHU #1 is contained within fan enclosure #1 and serves the 2nd floor administrative offices, as well as several other areas within the medical center. This AHU has a rated airflow of 95,000 cubic feet per minute (cfm). AHUs #4, #5, and #6 are housed within fan enclosure #4. AHU #4 serves the 5th floor nursery, as well as several other areas, and has a common fresh-air intake with AHUs #5 and #6. The combined airflow for these three AHUs is 69,000 cfm. AHU #4 provides a single pass of fresh air through the areas that it serves (i.e., operating rooms) without recirculation, while AHU #1 uses recirculated air. The fresh-air intakes for these two AHUs are shown in Figure 1A.

An administrative office on the second floor of the facility (Room 2334) was chosen to evaluate AHU #1, and a nursery on the fifth floor (Room 5905) was chosen to evaluate AHU #4. Several air samples were collected prior to each SF_6 release to determine whether the exhaust emissions from the incinerator/scrubber stack contained any compounds which would potentially interfere with the SF_6 peak, no interfering compounds were found.

To determine if these AHUs did indeed serve the rooms indicated, tracer-gas was first released directly into the fresh-air intakes of the AHUs at an airflow rate of 4.9 milliliters per minute (ml/min) and then measured inside the fresh-air supply ducts of the corresponding room. In both cases, it was found that the AHU shown on the building drawings served the room in question. After shutting off the SF_6 flow into the AHU fresh-air intakes, the decrease in SF_6 concentration inside the fresh-air supply ducts was used to calculate the ventilation rate for each of the AHUs evaluated. This data is useful for estimating how long emissions might persist in an AHU if they were momentarily pulled into the fresh-air intake.

The concept of a dilution factor(2) can be used to calculate the minimum quantity of a contaminant needed to pollute a ventilation fresh-air supply above an odor threshold or for comparison to the environmental criteria. A definition of the dilution factor is contained within Appendix A.

To evaluate the potential for reentry of incinerator emissions, SF_6 was released directly into the incinerator/scrubber stack at an airflow rate of 1.0 lpm. The SF_6 concentration was then measured inside the air supply ducts of Room 2334 and Room 5905. Reentry measurements were performed during morning and afternoon time periods for both rooms and wind direction was estimated by observing the incinerator exhaust plume from the roof of the hospital. The average SF_6 concentration and standard deviation was calculated.

C. Medical

Employees in the Nursery, Pediatrics, and Materials Delivery Departments (areas reported to be most affected by odors) were randomly selected from a departmental list of hospital personnel. Eight workers participated in confidential informal interviews in which they were asked if they had experienced any illness that they would attribute to foul or noxious odors. Two workers regularly experienced nausea, headache, dry scratchy throat, and burning eyes due to odors in their work area. Each of the remaining six employees interviewed could recall incidents where odors could be detected; however, with the exception of specific concerns about the Neonatal Intensive Care Unit (NICU), these were discrete events that neither occurred on a regular basis nor could be consistently described as having a similar odor. Employees did describe a continuing problem of odors in the NICU, where odorous conditions have been serious enough for the hospital to evacuate and relocate patients until the condition abated.

Hospital incident reports were reviewed to determine if reports had been filed by employees who became ill because of odors. A review of 12 months of hospital records, revealed that incident reports did not include conditions arising from odor-related incidents. Only two odor-related incident reports could be recalled by the safety committee member responsible for collating these reports.

Only two persons of eight (25%) employees interviewed expressed any problem with odors. The two employees affected by odors described irritant responses (headache, dry scratchy throat etc.), conditions that should diminish if the source of the irritation is properly controlled. Since further medical follow-up of employees would probably not produce additional usable information, the medical evaluation of this hazard evaluation was discontinued, and efforts were directed at assessing the potential for reentrainment of incinerator emissions into the hospital's ventilation systems.

V. EVALUATION CRITERIA

A. Environmental Evaluation Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Recommended Exposure Limits (RELs),[3] 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs),[4] and 3) the U.S. Department of Labor/Occupational Safety and Health Administration (OSHA) occupational health standards.[5] The OSHA standards may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH RELs, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is required by the Occupational Safety and Health Act of 1970 (29 USC 651, et seq.) to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high, short-term exposures.

B. Carbon Dioxide

Carbon dioxide (CO_2) is a normal constituent of exhaled breath that can be used as a screening technique to evaluate if adequate quantities of fresh air are being introduced into a building. For example, the outdoor ambient concentrations of CO_2 is usually 250-300 parts per million (ppm). If the indoor CO_2 concentration was determined to be 1000 ppm, or three to four times the outdoor concentration, inadequate ventilation would be suspected. CO_2 concentrations are generally higher inside than outside, even in a well ventilated building. It is not uncommon to find the inside concentration twice the outside concentration in a building with no reported health complaints. A high concentration of CO_2 may indicate that concentrations of other contaminants in the building may also be increased.[(6)]

C. Temperature and Relative Humidity

The majority of references addressing temperature and humidity levels as they pertain to human health frequently appear in the context of assessing conditions in hot industrial environments. However, the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) has published guidelines describing thermal environmental conditions for comfort (ASHRAE Standard 55-1981, Thermal Environmental Conditions for Human Occupancy).[(7)] These guidelines are intended to achieve thermal conditions that will be found acceptable or comfortable by at least 80% of the populations. Development of a "comfort" chart by ASHRAE presents a comfort zone considered to be both comfortable and healthful. This zone lies between 73° and 77° F (23° and 25° C) and 20% to 60% relative humidity.

D. Heating Ventilating and Air-Conditioning (HVAC) Systems

The outside air ventilation criteria recommended by NIOSH are those published by the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) in the ASHRAE Standard on Ventilation for Acceptable Indoor Air Quality (ASHRAE 62-1989).[(8)] Table 2 of that document specifies outdoor (fresh) air requirements for ventilation in commercial facilities. ASHRAE recommends a variety of fresh-air ventilation rates for different areas within a hospital environment (e.g. operation rooms, administrative offices).

VI. RESULTS

A. Carbon dioxide, temperature and relative humidity.

Carbon dioxide, temperature and relative humidity results are presented in Table I. Carbon dioxide sampling results show that outdoor CO_2 concentrations were about 400 ppm, and indoor concentrations ranged from about 575 ppm to 850 ppm. As the indoor CO_2 concentration approaches and exceeds 1000 ppm there is an indication that inadequate amounts of fresh air were being delivered to those areas.

Temperature readings ranged from 63° to 81° F and relative humidity from 47% to 61%. The temperature readings were generally within the comfort zone; however, temperature readings in Patient Accounts and Medical Records on Wednesday April 5, 1989, were 80° F and above.

B. Particulates/metals.

The highest detectable airborne concentrations of total [0.28 milligrams per cubic meter (mg/m^3)] and respirable (0.12 mg/m^3) particulates were less than 5% of the NIOSH REL of 10 mg/m^3 and 5 mg/m^3, respectively. The highest concentrations found were in the incinerator/scrubber penthouse, which could be considered an industrial type environment. All samples collected in office spaces or patient areas were less than l% of the NIOSH RELs. It should be noted that the NIOSH RELs, ACGIH TLVs, and OSHA PELs are generally designed for "industrial" environments (i.e., incinerator room), and are not adequate for assessing the indoor air quality of "non-industrial" areas (i.e., the nursery, patient rooms, administrative offices).

These samples were further analyzed via ICP-AES for 30 metals; however, only three of 27 sample results reported are considered valid results. Two numerical sequences of filters (5700s and 6000s) were used when collecting these samples, and all ICP-AES analytical results for filters in the 5700 series are considered invalid results because the total mass of metals detected on those samples far exceeded the total mass quantity reported by the laboratory on the gravimetric analysis. Also, all filters in the 5700 series showed that the concentrations of aluminum, calcium, and phosphorus taken individually exceeded the total mass quantity of the gravimetric analyses. Possible explanations include, a laboratory error when weighing the filters before or after sampling, or when conditioning the filters. These samples were not repeated because it was already proven that reentrainment of incinerator exhausts is possible under certain meteorological conditions.

C. Qualitative/quantitative screening for volatile organic chemicals.

General-area air samples collected for qualitative screening for volatile organic chemicals showed that all samples contained toluene, xylenes, isopropanol, some C_5 - C_6 alkanes, and a series of various aliphatic hydrocarbons, mostly branched alkanes in the C_{10} - C_{13} range. Additionally, one sample collected in Room 2044 (Patient Accounts) contained trichloroethylene, 1,1,1-

trichloroethane, limonene, and small amounts of $C_{16}H_{18}$ isomers such as phenylxylethanes (compounds often found in carbonless copy papers).

Based on the results of the qualitative screenings for volatile organic chemicals, 23 quantitative samples were analyzed for isopropanol, 1,1,1-trichloroethane, trichloroethylene, toluene, xylenes, limonene, and total hydrocarbons. The results of the quantitative analyses showed detectable concentrations of toluene on all full-shift samples collected, but only one sample had a quantifiable concentration, and was less than 1% of the NIOSH REL. Xylene was detected on 15 samples, but only three samples showed quantifiable concentrations, the highest of which was less than 1% of the NIOSH REL. Isopropanol was detected on seven samples and the highest concentration found was less than 1% of the NIOSH REL. Trichloroethylene was detected on two samples and 1,1,1,-trichloroethane was detected on three samples. Both substances were found only in Room 2044 (Patient Accounts) and Room 2046 (Medical Records) in concentrations less than 1% of the NIOSH REL. The highest concentrations of total hydrocarbons and xylenes were found at the Nurses Station 4A and Nurses Substation 4A. However, the sample concentrations detected were all less than 1% of the environmental criteria used and the samples were collected on a day when some patient rooms in these areas were being painted.

D. Tracer-gas Evaluation

1. AHU #4.

SF_6 was released directly into the fresh-air intake for AHU #4, and air samples collected inside the air supply duct to Room 5905 (the nursery) showed an SF_6 concentration of 3.6 ppb. AHUs #4, #5, and #6 are all contained within fan enclosure #4, and all have a common fresh-air intake. The combined airflow rate for these three AHUs was 69000 cfm. The mathematically calculated SF_6 concentration inside the fresh-air supply duct to Room 5905 was 2.5 ppb. The close agreement between the actual and calculated concentrations might be because AHU #4 is a one pass system without recirculation. The decay of SF_6 concentration with time was also evaluated and is shown graphically in Figure 2. These data are useful for estimating the amount of time a contaminant entering the fresh-air intake of an AHU would remain within the ventilation system before being completely cleared. This graph shows that it would take about 22 minutes to clear 90% of the SF_6 from this AHU

Table II shows the SF_6 concentrations measured inside the air supply duct to Room 5905 for the time periods when SF_6 was released directly into the incinerator/scrubber stack. On the afternoon of April 4 and the morning of April 5, 1989, SF_6 was released into the incinerator/scrubber stack and measured in the fresh-air supply duct to Room 5905. Figures 3 and 4 show the wind directions for these time periods. On the afternoon of April 4, measurable SF_6 concentrations were found in the fresh-air supply ducts to Room 5905. On the morning of April 5, before SF_6 was released into the incinerator/scrubber stack, measurable SF_6 concentrations were found in the fresh-air supply duct to Room 5905. The source of SF_6 is not known; however, it may have been left from the release on the afternoon of April 4.

After SF_6 concentrations had returned to clean background air concentrations (nondetectable concentrations), SF_6 was released into the incinerator/scrubber stack and no measurable SF_6 concentrations were found the remainder of that morning. The wind was observed blowing the incinerator/scrubber stack emissions away from the fresh-air intake for AHU #4.

2. AHU #1.

SF_6 was released directly into the fresh-air intake for AHU #1 and air samples collected inside the air supply duct to Room 2334 (an administrative office) showed an SF_6 concentration of 6.5 parts per billion (ppb). When the rated airflow of 94500 cfm was considered, the calculated concentration would have been 1.8 ppb. The actual concentration was approximately three times higher than the calculated concentration, possibly because the air from this AHU is recirculated. Figure 2 shows that it took about seven minutes to clear 90% of the SF_6 from the AHU.

Table II shows the SF_6 concentrations measured inside the air supply duct to Room 2334 for the time periods when SF_6 was released directly into the incinerator/scrubber stack. The values shown include the mean concentration, the standard deviation, and the range of concentrations. These data show that SF_6 concentrations measured the afternoon of April 5, 1989, were highest when the wind was blowing the stack emissions in the direction of the fresh-air intakes for AHU #1 (the prevailing wind direction for April 5, is shown in Figure 4). On the morning of April 6, 1989, when the wind was blowing the stack emissions away from the AHU fresh-air intakes, no detectable SF_6 concentrations were measured (the prevailing wind direction for April 6, is shown in Figure 5). When the wind shifted, blowing the stack emissions in the direction of the fresh-air intakes, SF_6 was detected for a brief period and then decreased when the wind shifted back, blowing the incinerator emissions away from the AHU fresh-air intake (the change in wind direction with time is also shown in Figure 5.)

VII. DISCUSSION

The dispersion of the incinerator exhaust plume is affected by several factors, such as stack velocity, stack height, wind direction, and speed. Additionally, the composition of the incinerator emissions being exhausted is affected by the burn rate and temperature. If properly operating, the scrubber should remove most particulates and vapors.

At the time of the NIOSH survey, the hospital was licensed to burn 175 pounds of infectious waste per hour in this incinerator. It appeared that much more waste was generated during our survey than could possibly be burned and stay within the (175 pounds per hour) limits of the hospital's incinerator permit. The amount of red-bagged waste generated was so great that the waste was stacked in the incinerator room and the adjacent stripping room.

The incinerator operator was provided with a full-face respirator equipped with a dust, fume, and mist cartridge, and other hospital employees, such as the hospital exterminator were seen wearing a respirator during the time of these surveys. However, a written respiratory protection program was not in place, and the incinerator operator had not been fit-tested or medically evaluated to determine his physical ability to wear a respirator. The employee was simply given a respirator, and told to use it, without formal training. Further, the respirator was not properly stored, nor cleaned regularly.

Tracer-gas sampling in rooms served by AHU #1 and AHU #4 showed that reentry of incinerator/scrubber stack emissions occurred under certain meteorological conditions. However, the calculated dilution factors are large; therefore, the emissions should be greatly diluted. On the days studied, the wind conditions present in the morning tended to blow incinerator/scrubber stack emissions away from the AHU fresh-air intakes, resulting in little or no reentry. However, prevailing winds in the afternoon blew the incinerator/scrubber stack emissions toward the AHU fresh-air intakes, resulting in reentry.

The dilution factors given in Table II apply only for the meteorological conditions present at the time of the NIOSH study. It is possible that under other meteorological conditions much greater concentrations of incinerator/scrubber stack emissions could be drawn into the fresh-air intakes of the hospital ventilation systems. A low wind speed blowing the incinerator/scrubber stack emissions directly at the AHUs fresh-air intakes might result in much lower dilution factors and, therefore, much greater contamination of the hospital ventilation systems.

Work practices should be instituted to require that the incinerator is operated at the proper burn rate to insure the most efficient burning of waste. This would insure that the incinerator emissions would be minimized and that the incinerator scrubber would be capable of operating at optimal efficiency. Increasing the stack height or modifying the AHUs fresh-air intakes might help minimize reentry of incinerator/scrubber stack emissions.

VIII. CONCLUSIONS

The tracer-gas evaluation showed that reentrainment of incinerator/scrubber stack emissions was possible under certain meteorological conditions. When the wind was blowing the incinerator/scrubber stack emissions toward the AHU fresh-air intakes, it was shown that SF_6, and therefore incinerator/scrubber stack emissions, was drawn into the fresh-air intakes and into the hospital ventilation systems.

There were no documented overexposures to any chemical substances included in the sample analyses. However, the temperature and relative humidity readings in some office areas exceed the ASHRAE recommendations for thermal comfort. All industrial hygiene sample results were less than 5% of the relevant NIOSH RELs, ACGIH TLVs, and OSHA PELs, and most were less than 1% of these environmental criteria. However, it should be noted again that these criteria are generally designed for "industrial" environments (i.e., incinerator room), and are not adequate for assessing indoor air quality of "non-industrial" areas (i.e., the nursery, patient rooms, administrative offices). Indoor air quality complaints sometimes occur when a large number of airborne contaminants are present at concentrations well below the "industrial" criteria cited above. However, the low concentrations found would not be expected to cause employee health problems.

The incinerator operator was required to wear respiratory protection when working at the incinerator; however, a written respiratory protection program had not been established. The employee had not been fit-tested to assure a proper respirator fit, medically evaluated to determine if he was physically capable of wearing a respirator, or trained in the proper use and care of a respirator, as required by OSHA regulations (29 CFR 1910.134). Additionally, at least one other hospital employee was required to wear a respirator.

IX. RECOMMENDATIONS

1. A written respiratory protection program should be established and enforced and should comply with all aspects of the OSHA Respirator Standard, 29 CFR 1910.134.

2. Temperature and relative humidities in patient areas, office spaces, and all areas of the hospital should be monitored and maintained with the ASHRAE recommendations for thermal comfort.

   Although, it is our understanding that this hospital's pathological waste incinerator was shut down shortly after the NIOSH survey, the following recommendations should be instituted if the incinerator is ever restarted.

3. Work practices should be instituted to insure that the incinerator is operated at the proper burn rate to minimize emissions.

4. The effect of incinerator/scrubber stack height or modification of AHU air intakes should be evaluated to determine if increasing the stack height or modifying the AHU fresh-air intakes would help minimize reentry of emissions from the incinerator/scrubber stack into the AHU fresh-air intakes.

X. REFERENCES

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4. Chairman, Environmental Conservation Committee, New York State Assembly, Albany, New York.
5. State of New York, Department of Health, Albany, New York.
6. OSHA Region II.
7. NIOSH Boston Region.

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table I

Direct Reading Carbon Dioxide Measurements

Lutheran Medical Center
Brooklyn, New York
HETA 88-314

April 5, 1989

Room No./Area	Time	Carbon Dioxide (ppm)
1125	10:25	575
Corridor of 4th Floor CCU	10:50	700
Main Nurses Station - 4A	11:00	675
RN Sub-station - 4A	11:10	750
RN area 5900	11:20	800
RN area 5900/west end	11:25	700
5905 - Nursery	11:27	675
RN station - 5F	11:29	850
Corridor/5620, 5622	11:30	825
Corridor/5902, 5936	11:33	825
Corridor/5914, 5916	11:35	800
RN station - 5E/5516, 5518	11:36	625
RN station - 5E/5538	11:38	675
Maternity waiting area, 5801A	11:40	725
RN station 5C/5337	11:43	700
RN station 4C/4307	11:47	625
RN station 4C/4343	11:49	625
RN station 4D/4407	11:51	675
Corridor/4422, 4418	11:52	575
Corridor/4434, 4432	11:54	675
Corridor/4335	11:58	675
1125	3:14	525
Patient accounts, reception, 2044	3:19	675
" " , copier	3:21	625
" " , annex	3:50	650
" " , back center (smoking allowed)	3:23	625
Medical records, 2046	3:33	625
" " , middle of room	3:35	625
" " , back of room, window open	3:37	500
On roof top	3:42	400

Abbreviations:
ppm - parts of carbon dioxide per million parts of air

Table II

Sulfur hexafluoride (SF_6) Concentrations For Various Time Periods

Lutheran Medical Center
Brooklyn, New York

HETA 88-314

Air Handler (Room)	Date	Time	Wind Direction	Range (N)	SF_6 Concentration (ppb) (Mean +/ Standard Deviation)
AH #1 (2334)	4/5	16:15-16:50	Figure 4	.064-.10 (12)	$0.085 \pm .010$
AH #1 (2334)	4/6	09:20-10:00	Figure 5	<.01->.18 (9)	$0.063 \pm .069$
AH #4 (5905)	4/5	11:00-11:50	Figure 4	<.01 (11)	< 0.010
AH #4 (5905)	4/4	16:50-17:50	Figure 3	.056-.25 (14)	$0.105 \pm .05$

Dilution Factors for Various Time Periods

Air Handler (Room)	Date	Time	Dilution Factor
AH #1 (2334)	4/5	16:15-16:50	1.12×10^5
AH #1 (2334)	4/6	09:20-10:00	1.51×10^5
AH #4 (5905)	4/5	11:00-11:50	$>1 \times 10^6$
AH #4 (5905)	4/4	16:50-17:50	9.1×10^4

N - number of measurements

LOCATION OF AIR HANDLER INLETS RELATIVE
TO INCINERATOR STACK

LUTHERN MEDICAL CENTER
BROOKLYN, NEW YORK
HETA 88-314

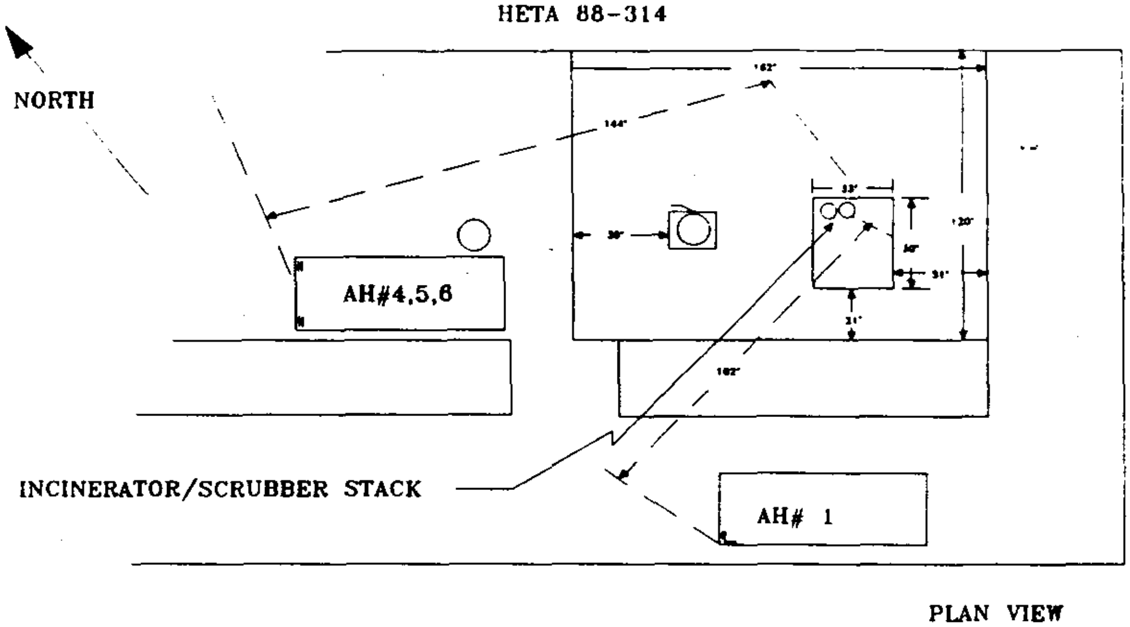


FIGURE 1A

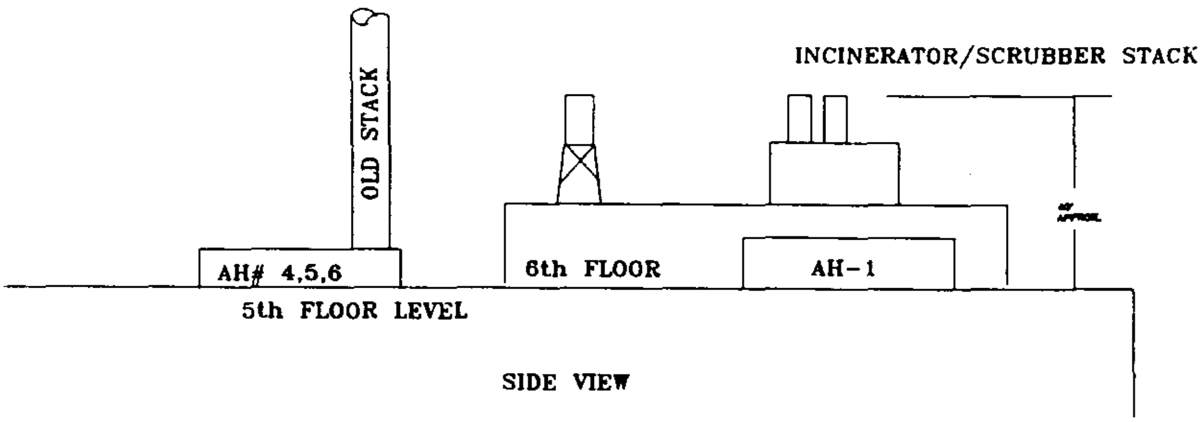


FIGURE 1B

SF_6 CONCENTRATION DECAY

LUTHERAN MEDICAL CENTER

BROOKLYN, NEW YORK

HETA 88-314

APRIL 4-6, 1989

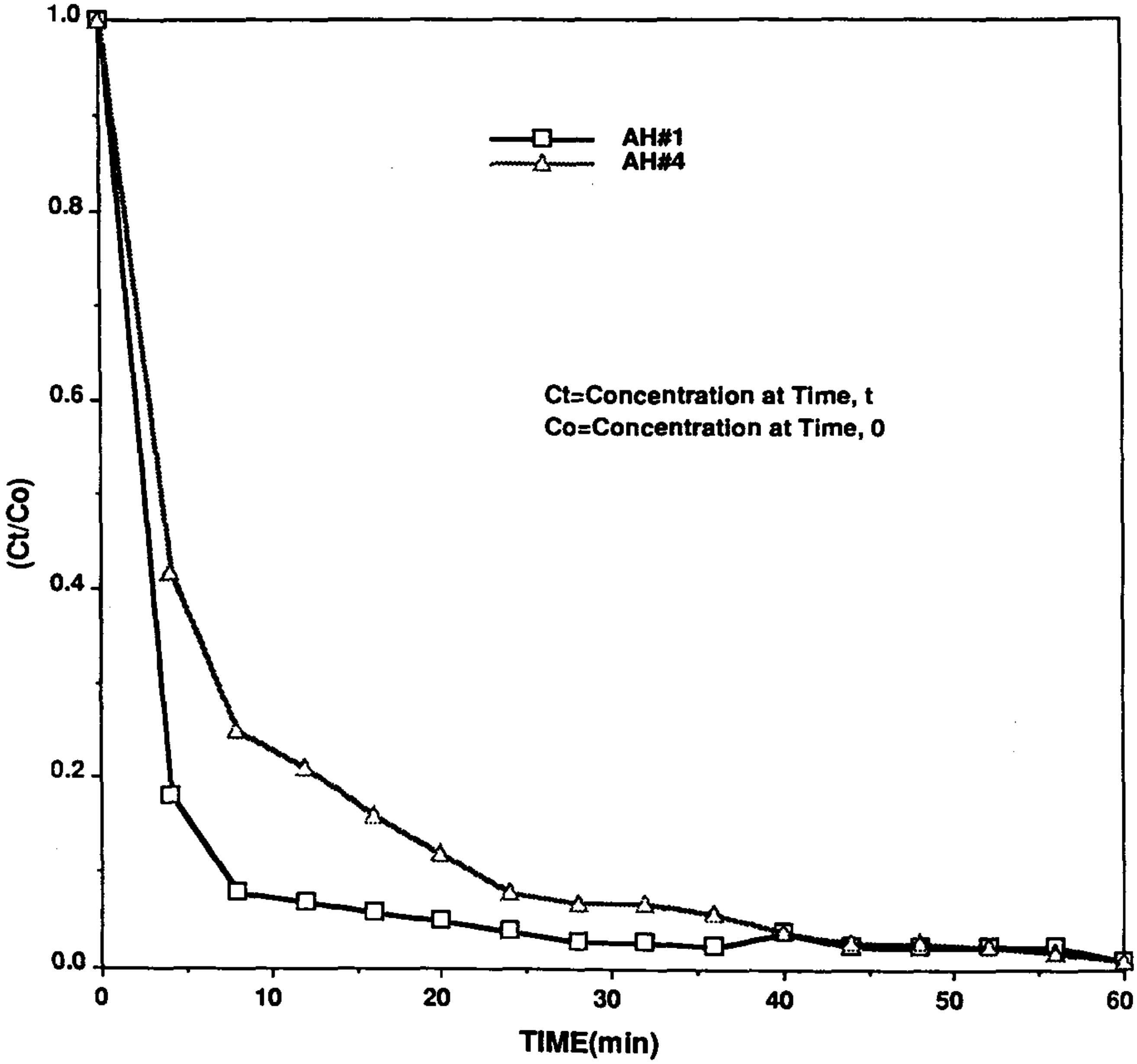
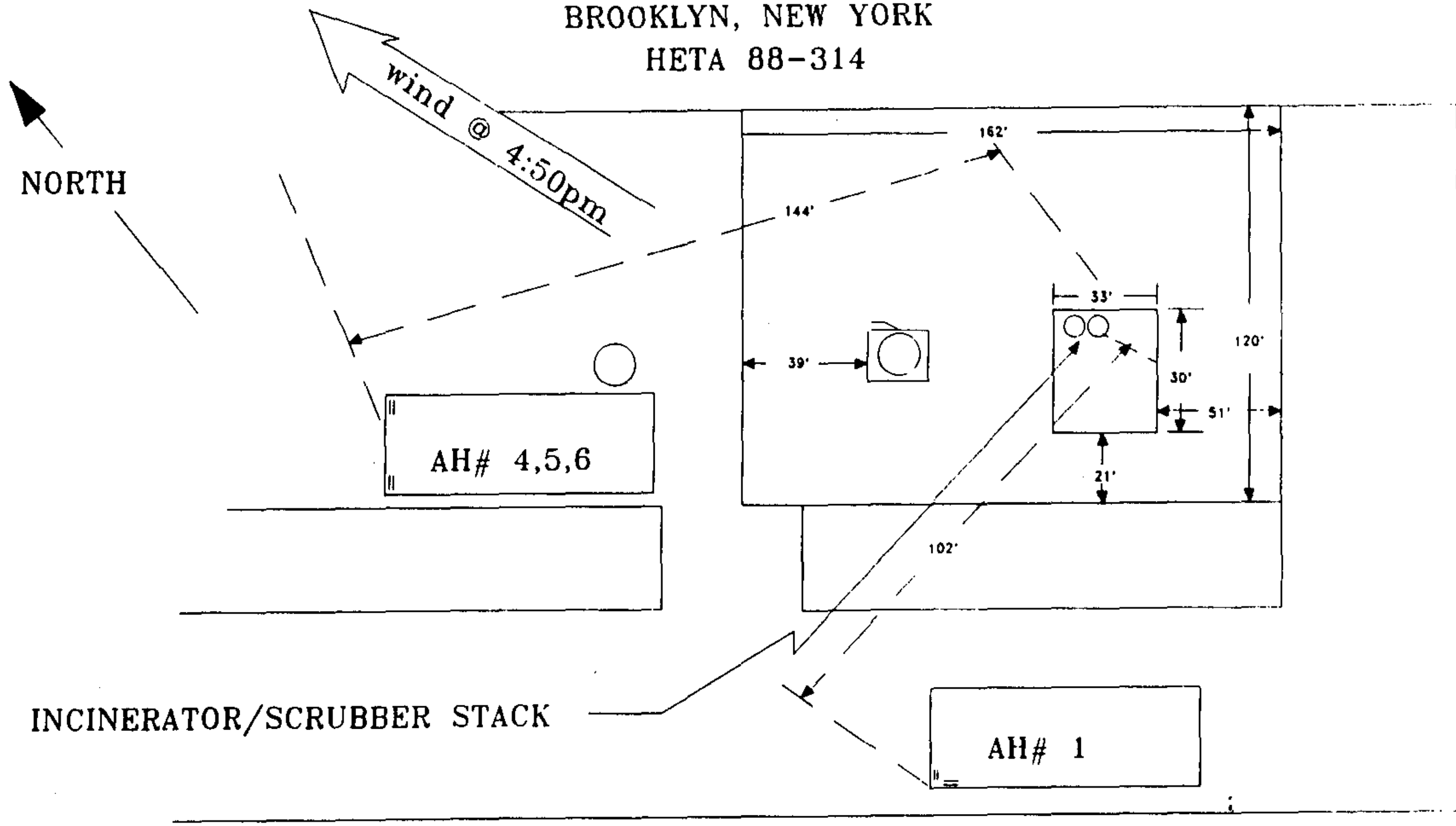


Figure 2

LOCATION OF AIR HANDLER INLETS RELATIVE
TO INCINERATOR STACK
LUTHERN MEDICAL CENTER
BROOKLYN, NEW YORK
HETA 88-314



‖ = Fresh-air Intake

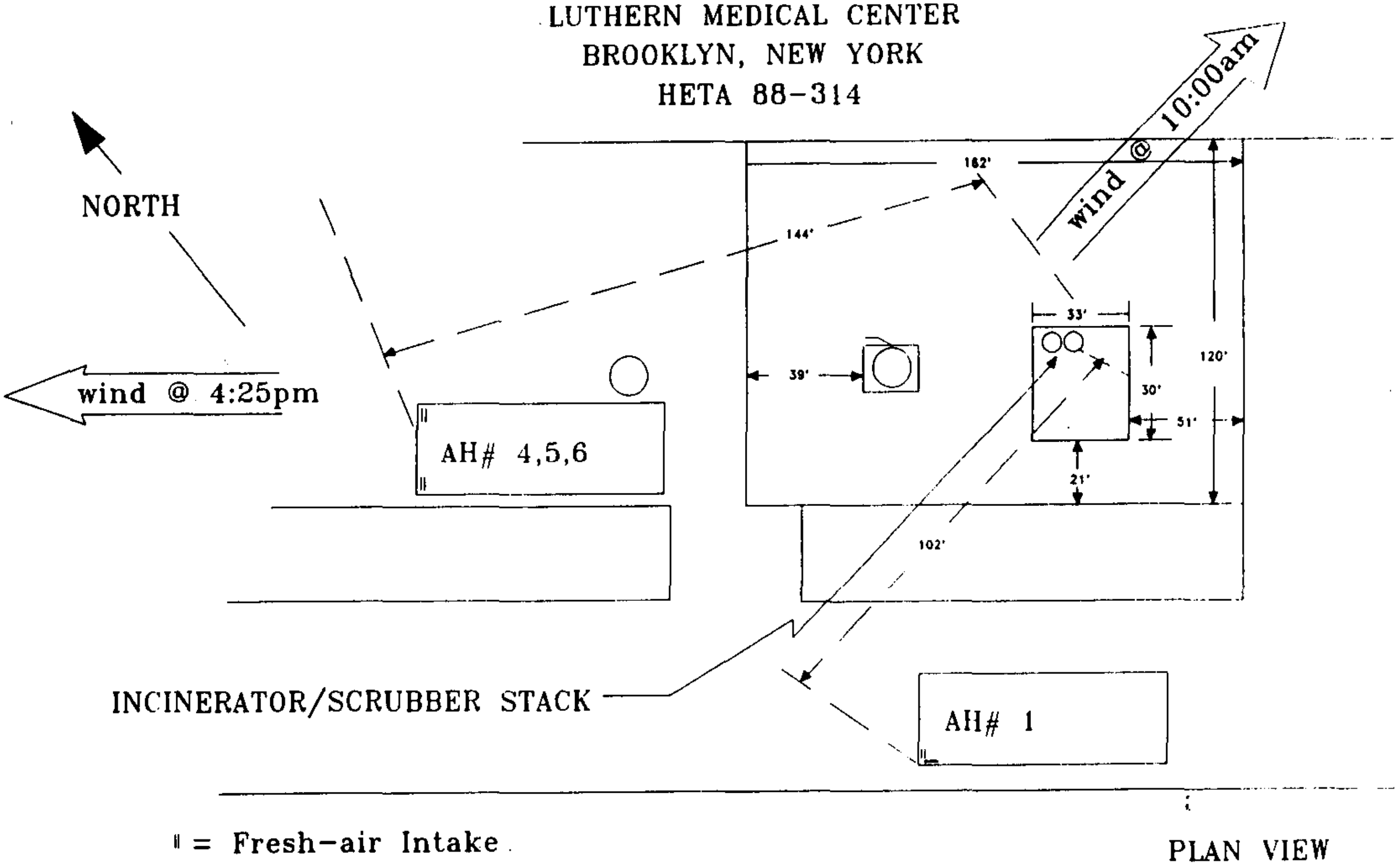
PLAN VIEW

WIND DIRECTION 4-4-89

Figure 3

LOCATION OF AIR HANDLER INLETS RELATIVE TO INCINERATOR STACK

LUTHERN MEDICAL CENTER
BROOKLYN, NEW YORK
HETA 88-314

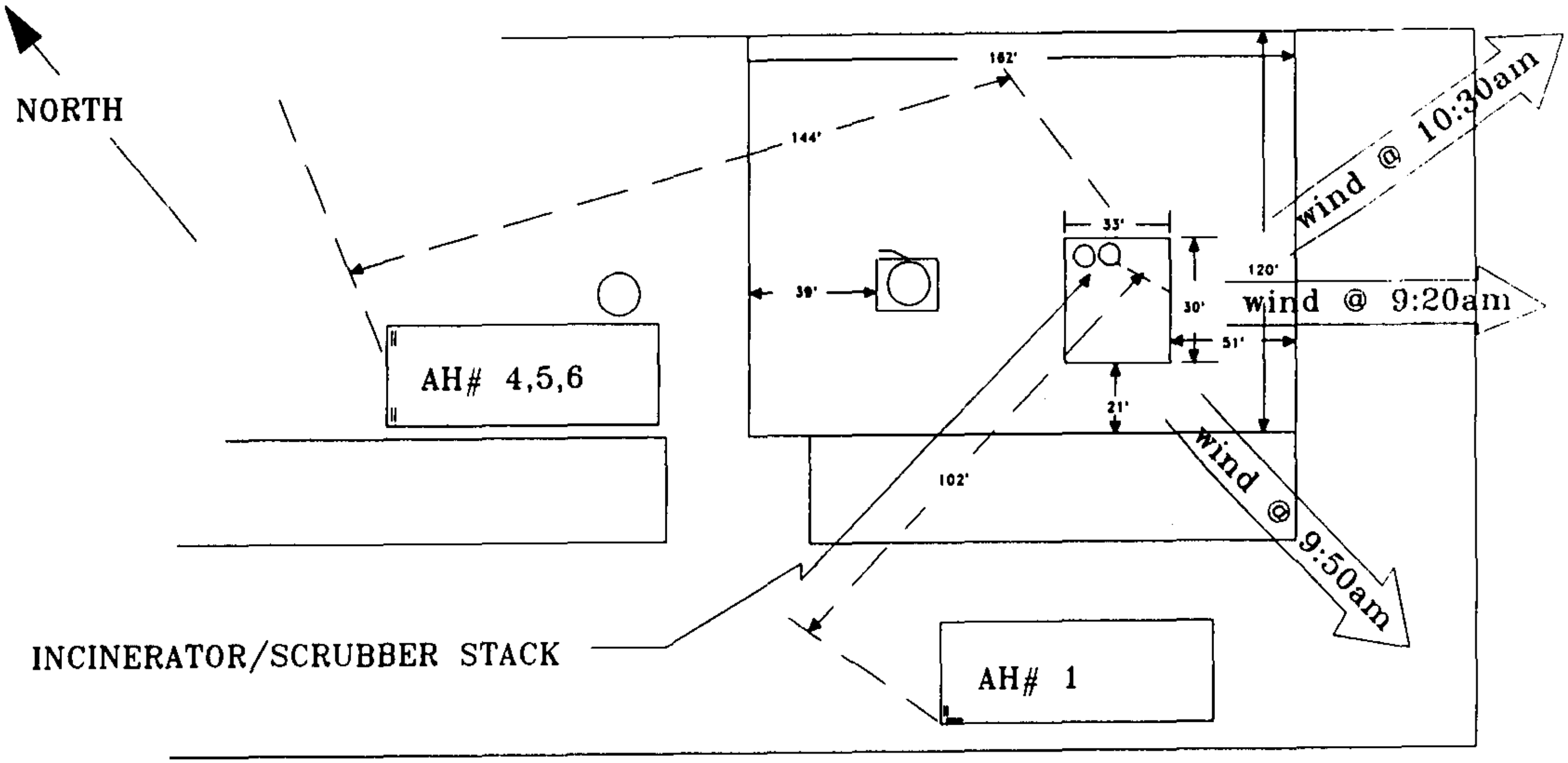


WIND DIRECTION 4-5-89

Figure 4

LOCATION OF AIR HANDLER INLETS RELATIVE
TO INCINERATOR STACK

LUTHERN MEDICAL CENTER
BROOKLYN, NEW YORK
HETA 88-314



‖ = Fresh-air Intake

PLAN VIEW

WIND DIRECTION 4-6-89

Figure 5

APPENDIX A

Dilution Factor Definition

The dilution factor, D, is based on a contaminant concentration in a ventilation system exhaust and is defined as follows:

$$D = \frac{\text{Contaminant concentration in exhaust system}}{\text{Contaminant concentration found in fresh air supply}} \qquad \text{(A-1)}$$

It is assumed that the tracer gas is uniformly dispersed across the sampling area.

Then, the vaporous contaminant emission rate from individual exhausts which would result in TLV levels of that contaminant in the air supply may be calculated by:

$$dv = \frac{LIM}{1000} \times \frac{MW}{24.45} \times D \times Q \times \frac{1}{1-h} \qquad \text{(A-2)}$$

where dv = Contaminant emission from stack exhaust at 25° C and 760 mm Hg (g/min)
MW = Contaminant molecular weight
LIM = ACGIH TLV, OSHA PEL, NIOSH REL, or odor threshold (ppm)
Q = Actual exhaust flow rate at 25° C and 760 mm Hg (m^3/min)
D = Dilution factor
h = Filter efficiency